May 1992

BEST PRACTICE PROGRAMME

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Good Practice Case Study

ENERGY EFFICIENCY IN OFFICES

CONDENSING GAS BOILERS

Condensing gas boilers for heating and hot water in offices

- **Cost savings of 10-20%**
- **Paybacks under 5 years**
- **High efficiencies using conventional design**
- **Easy to install and maintain**

On average, offices use about 220 kWh/m²/yr (costing about £3/m²/yr) in providing space heating and domestic hot water. This can account for up to 50% of the total energy costs in this type of building and is potentially one of the most controllable overheads in any office budget. There is a common feeling that office overheads are too large and many building managers are asking what they can do about these costs. Installing condensing gas boilers can be a good way to address this problem as cost savings are generally 10-20% of the annual boiler fossil fuel bill.

On a national basis, office heating and hot water costs roughly £300M each year which represents a significant part of the UK energy consumption in buildings. Of this total demand, roughly one third is met by heating plant that is suitable for replacement by condensing boilers. Therefore, based on a conservative 10%, £10M could be saved each year in offices through the use of condensing boilers. In general the necessary additional investment would be repaid within five years.

The condensing boilers at Solihull Metropolitan Borough Council.

The overall energy consumption in offices for heating and hot water results in around 4M tonnes of CO_2 being emitted into the atmosphere every year, adding to the greenhouse effect. Using condensing boilers could reduce this by up to 100,000 tonnes/yr and would also help prevent acid rain. Condensing boilers are therefore much less harmful to the environment than conventional heating methods.

Examples of good practice using condensing boilers are given overleaf. The results show that condensing boilers can offer attractive investment opportunities in a wide range of circumstances.

Council House Solihull Metropolitan Borough Council

BEST PRACTICE PROGRAMME

Energy Efficiency Office
DEPARTMENT OF THE ENVIRONMENT

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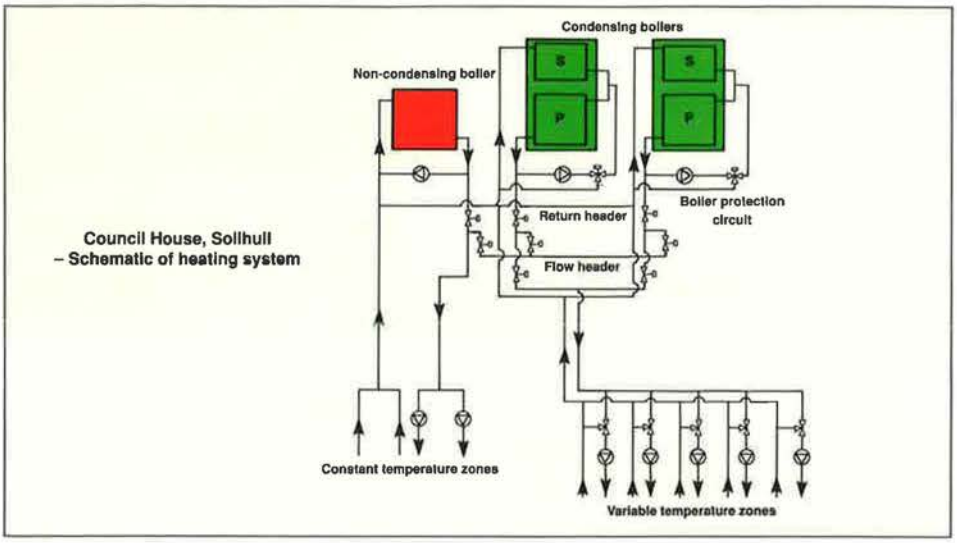
COUNCIL HOUSE — SOLIHULL



Council House, Solihull – Schematic of heating system

Schematic of the heating system at the Council House, Solihull

COUNCIL HOUSE, SOLIHULL METROPOLITAN BOROUGH COUNCIL

The main offices of Solihull Metropolitan Borough Council are known collectively as 'Council House' and are situated in the centre of the town. The complex consists of three main buildings; Churchill House, the Civic Suite and Orchard House, providing a floor area of approximately 12,750 m². These offices accommodate all the main local government departments such as Town Clerk, Technical Services, Finance, Education, Social Services and Housing. The buildings accommodate around 800 people between 08.00 and 17.00 during weekdays. The Civic Suite houses the council chambers and committee rooms which are commonly used for meetings late into the evening.

Churchill House is a medium weight seven storey office block typical of the 1960's. It has a concrete frame with brick cladding and a slightly pitched roof. The building is said to require long heating periods due to the large area of glazing and leakage around window frames. The Civic Suite is a separate two storey building of a similar construction, also built in the mid 1960's. Orchard House was built in 1986 and joins with Churchill House to form the majority of a quadrangle. It is a medium weight construction on three storeys with a pitched slate roof.

System

Until summer 1988 the offices were heated by steam boilers situated in the adjacent conference centre. Steam was supplied to a calorifier room located in the basement of Churchill House. This in turn supplied LPHW to the heating system. The steam boilers became difficult to maintain and separate LPHW boiler plant was therefore required to supply the Council House complex independently. The council's in-house design team decided to install the most energy-efficient means of supplying the existing heating system. Gas-fired condensing boilers proved to be the most cost-effective option that they considered.

Four Broag boilers were installed in place of the steam calorifier plant. They comprise two OD15A/9ECO condensing boilers rated at 775 kW each and one OD15A/9 conventional boiler rated at 775 kW supplying space heating. The fourth boiler is an OD13A/6 rated at 116 kW which supplies domestic hot water (DHW) only, via two 1500 litre storage vessels. All the boilers have forced draught High/Low burners and the condensing economisers are supplied as additional items. The boilers are of cast iron sections and the condensing economisers consist of coated aluminium tubes.

A main header in the plant room links the individual boiler flues. The conventional boiler is farthest from the main flue stack, avoiding wet combustion gases reaching the cast iron sections. A common flue stack rises the full seven storeys in single skin stainless steel with an outer brick cladding. No additional fans were required on the flue system. The flue was constructed in 6m lengths to minimise the number of joints in the brick stack. Three inspection hatches in the brick stack allow access in case condensate should leak from the joints. As a deliberate policy, there is no flue terminal in order to ensure good dispersal of the low temperature flue products. The boilers and flues have separate condensate drains made of standard plastic waste pipe. Each drain has a trap to avoid leakage of combustion products into the plant room.

The space heating system has seven main zones. Churchill House has five weather compensated zones. The Civic Suite and Orchard House are the remaining zones which are supplied with constant temperature LPHW. The Orchard House zone then splits into a further seven variable temperature zones. Churchill House and Orchard House are wholly served by radiators whilst the Civic Suite requires constant temperature hot water to supply air handling plant.

The boilers are controlled using a JEL Building Energy Management System (BEMS) and are sequenced to allow the condensing boilers to take all the Churchill House load. However, as shown opposite, the system also allows them to take the load on the constant temperature circuits if they are free to do so. The boilers have optimum start/stop controls and the majority of the system is under weather compensation control. The occupancy times for the condensing boilers are between 07.00 and 17.00 Monday to Friday. The non-condensing boiler is operated between 06.00 and 22.00 to provide constant temperature heating during council meetings.

Economics

The boilers condense for significant periods in the heating season due to the variable temperature circuits in Churchill House. The simple payback achieved is estimated to be around 4.4 years which indicates the benefits of these highly efficient boilers. The flue would have been more expensive had conventional boilers been used because a twin wall system would have been installed.

Reactions

Engineers in Solihull's building services team feel that their original design concept appears to be working well. The system has proved to be reliable and the building manager is very happy with its operation.

The staff involved have indicated that there were no major installation problems and no additional maintenance costs have come to light. Solihull Council would certainly do the same thing again, and now consider condensing boilers for every site as a matter of course.

Weetabix offices

WEETABIX LIMITED, KETTERING

Established in the 1930's, Weetabix is the largest British owned breakfast cereal manufacturer. The head office and principal manufacturing facility are located on a 55 acre site near Kettering. The site as a whole supports 1500 employees and has a central high pressure steam boiler plant.

Due to changes in building use, Weetabix needed to re-route part of the large steam main. It was an ideal time to consider decentralising some of the nearby space heating loads. Two medium sized offices were isolated from the steam system and condensing gas boilers replaced the steam/LPHW calorifier. A full and detailed appraisal showed Weetabix the sound economic sense in opting for these high-efficiency appliances.

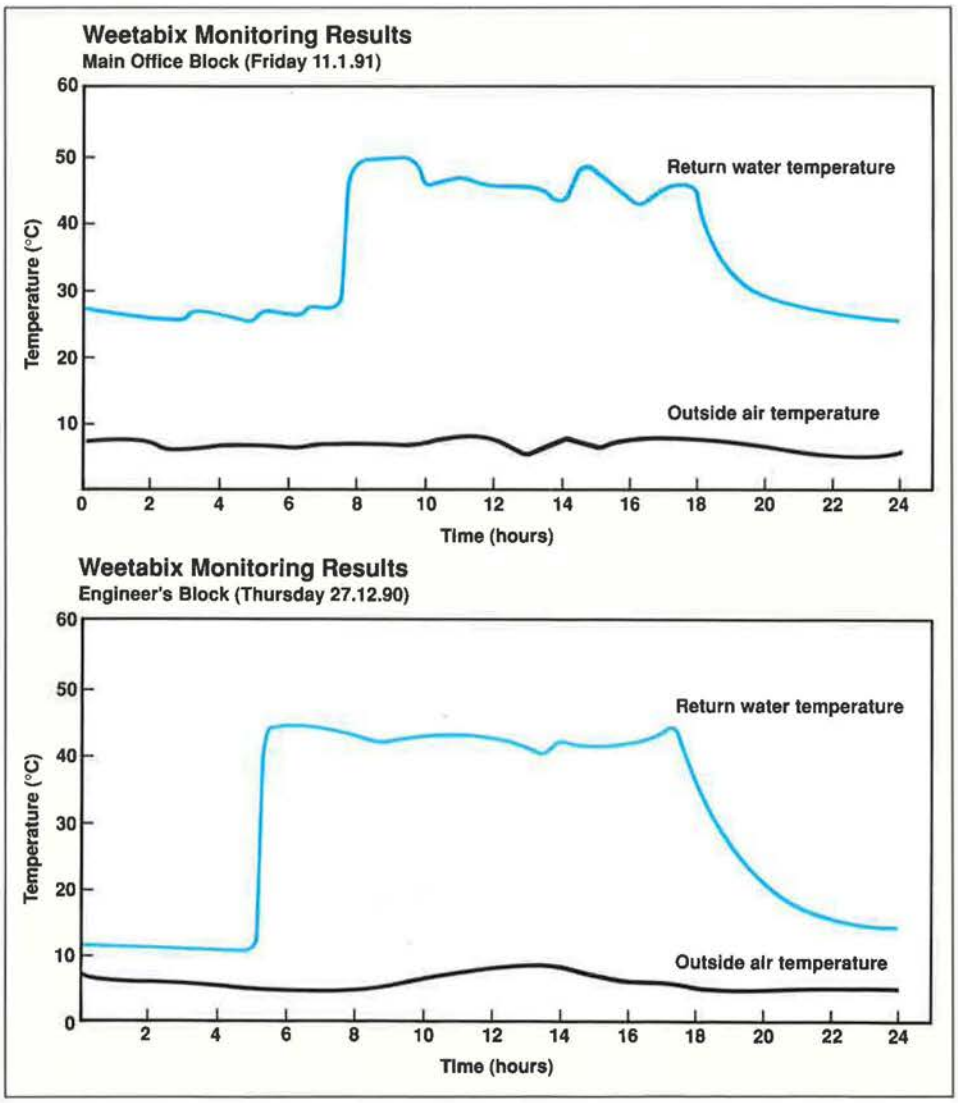
The Engineering Block, which is the larger of the two buildings, now has a condensing boiler. These offices accommodate between 60 and 70 people ranging from a purchasing department to production staff and a technical services group. It is used between 07.00 and 17.00, five days/week. The building is based around an old stable which has been added to over the years. In the main it is a two storey metal frame building with brick walls and pitched slate roofs. There are metal frame windows throughout, with secondary double glazing.

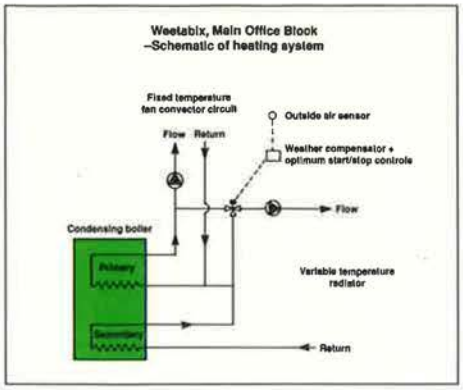
The Directors Block and the Main Block form the second office which now has a condensing boiler. This was built in the 1970's and accommodates around 40 to 50 people between 09.00 and 17.00. It is a two storey brick building with a flat roof.

System

Two Hoval condensing boilers were installed in the Autumn of 1990 in individual ground floor plant rooms. Both are natural draught units, based on a steel tube design with aluminium finned tube condensing heat exchangers

The Engineering Block has a Hoval GS225-plus gas-fired condensing boiler rated at 225 kW. It has a 200 mm single skin stainless steel flue rising two storeys. The Directors/Main Block has a Hoval GS150-plus condensing boiler rated at 150 kW. The flue rises only 2m in 150mm stainless steel and terminates just above the boiler house roof. The flues do not have terminals which helps to disperse the products of combustion. Each boiler has a condensate drain and trap run in ordinary plastic waste pipe.





Schematic of heating system

Both boilers supply space heating only, as DHW is supplied by local electric heaters. The Engineering Block system has panel radiators whereas the Directors/Main Block has a fan convector circuit alongside radiators. The fan convectors operate at constant temperature and hence this circuit is supplied by the primary section of the boiler only. The convectors probably amount to no more than 10-15% of the overall heating load.

The boilers were sized on the rating of the old steam calorifier and are therefore likely to be oversized. Equally, measures such as secondary double glazing and an original design safety margin have probably resulted in the radiators now being oversized. Whilst it is normally uneconomic to deliberately oversize radiators, it can add one or two percentage points to the resulting annual system efficiencies.

Each boiler has a weather compensator acting on a three-port valve to reduce flow water temperatures during mild parts of the heating season. Heat up periods are kept to a minimum by individual optimum start/stop controllers.

Economics

Both boilers were seen to condense on days with an outside air temperature of between 5 and 8°C and are understood to condense for the majority of the heating season. This is supported by monitoring results, as shown opposite.

The steam supplied to these buildings was costing just over £8,000 per annum. Estimates showed that installing new conventional boilers would provide a payback in around 3.5 years and condensing boilers in just over four years. Early energy consumptions indicate that the actual payback on the condensing boilers is around 4 years. This shows that in this type of office building condensing boilers can still achieve a reasonably good payback despite the relatively short heating period.

Reactions

Engineers at Weetabix are happy with the boilers and they are installing further condensing boilers on another site at Corby. Staff are also pleased that there is less maintenance than on the steam calorifier, which required regular pressure testing and insurance inspections.

The engineer involved found the system easy to design even though it was the first space heating system he had been associated with.

COUNTY HALL — TROWBRIDGE

COUNTY HALL, TROWBRIDGE, WILTSHIRE COUNTY COUNCIL

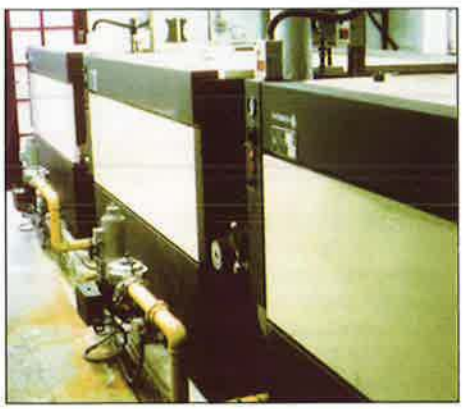
The County Hall site at Trowbridge consists of the original building built in 1939 and an extension block added in the mid 1970's. The two are linked by a bridge corridor but have entirely separate heating systems. The condensing boilers are in the original block. This is a heavyweight construction with a concrete frame and a Bath stone exterior with pitched tiled roofs. The building originally had four storeys; basement, ground, 1st and 2nd, but a fire in the late 1950's prompted refurbishment which included the addition of a 3rd floor in the roof space.

The original block now provides roughly 7,890 m^2 of office space and accommodates all the main departments of a large county council including Finance and Education. The building also houses a restaurant, the council chamber and committee rooms for executive meetings. Roughly 500 staff work on flextime in the old block, resulting in operating hours of 08.00-18.00. DHW is supplied using localised electric water heaters

System

Originally, two cast iron sectional boilers with underfeed stokers operated at 49°C. Sections of the boilers had to be replaced every five years due to condensation corrosion. In 1970 these were replaced with new oil-fired boilers and a three-port valve. This solved the corrosion problems but the boilers came to the end of their useful life in 1987. Condensing boilers were then installed.

In the summer of 1987 three De Dietrich DTG413C atmospheric gas-fired condensing boilers were installed each rated at 396 kW. These boilers have a cast iron primary and secondary heat exchanger with a High/Low firing facility.



Trowbridge County Hall boiler house

The two existing stainless steel flue liners were utilised for the condensing boilers, and the third boiler flue joins in the boiler room. The flue stack has no terminal and the boilers have individual plastic condensate drains.

The original heating system is ceiling heating which comprises pipes embedded into the concrete ceiling slabs. Radiators were installed in the third floor when it was turned into office space. The ceiling heating was designed to operate at a flow temperature of 49°C, with an upper limit of 54°C. The pumps were upgraded and the three-port valve removed when the condensing boilers were installed.

The original ceiling heating system was manually controlled by adjusting the boiler thermostats. This would begin at a flow temperature of around 38°C in Autumn and rise to 49°C in Winter. The single three-port valve was installed in 1970 but this was removed when the condensing boilers were installed and they are now compensated directly. With the exception of TRVs on the radiator circuit, there are no zone controls in the building. It was impractical to retrofit zone valves due to the nature of the ceiling heating system.

An Allen Martin BEMS monitors and controls the system. It provides direct weather compensation and optimum start/stop control. The boilers are sequenced and switch between high and low fire.

This heavyweight building was operating on a three day response time. The BEMS now has a large number of sensors to obtain a more representative average of the building temperature. These control improvements and the pump upgrade have reduced the response time to about one day.

Economics

The system condenses for a significant part of the heating season due to the low temperature ceiling heating and weather compensation controls. It is estimated that the boilers have paid for themselves in about 2.2 years which has come close to original expectations. A more rapid payback period could have been achieved by using a mixture of condensing and conventional boilers, with the condensing acting as lead boilers. However, this would have provided a slightly reduced overall efficiency.

Reactions

The Energy Manager of Wiltshire County Council is now far happier with the energy bills and believes it to be a very efficient office block. The system appears to be reliable and is clearly a good application of condensing boilers due to the low temperatures involved. No additional maintenance costs have come to light and Wiltshire is expecting the same life as conventional plant ie. 15 years.

	ESTIMATED ANNUAL RUNNING COST (Conventional System)	ESTIMATED ANNUAL COST SAVING (Condensing Element)	OVERCOST (Condensing Element)	APPROXIMATE PAYBACK PERIOD (Condensing Boiler)
SOLIHULL MBC	£21,100	£3,900	£17,000	4 Years
WEETABIX	£5,900	£920	£3,700	4 Years
WILTSHIRE CC	£37,800	£6,300	£14,000	2 Years

Further Information

This Good Practice Case Study is one of a series on energy efficiency in buildings. These include a number of condensing boiler Case Studies in other types of building. **Good Practice Guide 16** provides practical information on installing condensing boilers in large buildings. The Chartered Institution of Building Services Engineers (CIBSE) **Applications Manual AM3: Condensing Boilers** gives detailed guidance on all aspects of the subject. This covers appliance selection, new application yardsticks, system design and economic evaluation.

The information presented in this series of Case Studies has been taken from material provided by the users and from site visits carried out by independent consultants Building Energy Solutions. Where possible, economic figures have been calculated from the fuel bills. Estimates have been made in cases where these were not available. The co-operation of the owners, designers, managers and occupants of the Case Study buildings is gratefully acknowledged.

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